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ABSTRACT

This report is intended to provide statistical data that may be useful to organizations undertaking affirmative action programs with respect to minority groups. Its data are limited to the doctoral level (PhD, EdD, ScD and equivalent) but do not include such professional degrees as MD, DDS, DVM, or JD. It includes data on Blacks, Orientals, American Indians, and Latins (the latter term covering such groups as Mexican-Americans, Puerto Rican-Americans, Chicano), but it does not aim to include all possible minority groups within the U.S. population. There are no policy interpretations or recommendations included in this report. The literature review in the current report is very brief, limiting itself to other studies concerned with minority groups at the doctorate level that aim at an assessment of the numbers of persons in such groups. Almost 4,000 of the PhD's of fiscal 1973 in the U.S. were members of minority groups but only 37 percent of these were U.S. citizens. The Orientals were the predominant group, followed by Blacks, Latins, and American Indians, in that order. Appendices include estimation techniques, direct and indirect, and minority group estimates from incomplete data. A selected 11-item bibliography is included. (Author/PG)

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MINORITY GROUPS

Among United States Doctorate Level Scientists, Engineers, and Scholars, 1973

Prepared by the
Commission on Human Resources of the National Research Council

HE006938

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MINORITY GROUPS AMONG UNITED STATES DOCTORATE-LEVEL SCIENTISTS, ENGINEERS, AND SCHOLARS, 1973

Prepared by the

COMMISSION ON HUMAN RESOURCES

of the

National Research Council

National Academy of Sciences

Washington, D. C. December 1974

NOTICE

The project which is the subject of this report was approved by the Governing Board of the National Research Council, acting in behalf of the National Academy of Sciences. Such approval reflects the Board's judgment that the project is of national importance and appropriate with respect to both the purposes and resources of the National Research Council.

The members of the committee selected to undertake this project and prepare this report were chosen for recognized scholarly competence and with due consideration for the balance of disciplines appropriate to the project. Responsibility for the detailed aspects of this report rests with that committee--in this case the Commission on Human Resources.

Each report issuing from a study committee of the National Research Council is reviewed by an independent group of qualified individuals according to procedures established and monitored by the Report Review Committee of the National Academy of Sciences. Distribution of the report is approved, by the President of the Academy, upon satisfactory completion of the review process.

ADVISORY COMMITTEE ON THE STUDY OF MINORITY GROUPS AMONG UNITED STATES DOCTORATE-LEVEL SCIENTISTS, ENGINEERS, AND SCHOLARS, 1973

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PREFACE

This report is intended to provide statistical data which may be useful to organizations undertaking affirmative action programs with respect to minority groups. Its data are limited to the doctorate level, (PhD, EdD, ScD and equivalent) but do not include such professional degrees as MD, DDS, DVM, or JD. It includes data on Blacks, Orientals, American Indians, and Latins (the latter term covering such groups as Mexican-American, Puerto Rican-American, Chicano), but it does not aim to include all possible minority groups within the U.S. population.

There are no policy interpretations or recommendations included in this report. The National Board on Graduate Education plans to publish in the spring of 1975 a report which will deal with policy-related questions, as well as present extensive additional data, and a review of literature. The literature review in the current report is very brief, limiting itself to other studies concerned with minority groups at the doctorate level that aim at an assessment of the numbers of persons in such groups.

The present report was prepared by Lindsey R. Harmon, Director of Research, in collaboration with other members of the Commission's staff who were responsible for gathering the data. Norma Melendez prepared the programming for the tables and typed the manuscript.

Additional studies are under way in the Commission on Human Resources of the National Research Council, with a view to developing further the factual base regarding data about the numbers, education, and careers of members of minority groups within the scientific population at the doctorate level. As such further data become available, they will be published for the use of universities, government agencies, and others concerned with the full incorporation of minority groups within the mainstream of American society.

Robert A. Alberty
Commission on Human Resources

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MINORITY GROUPS AMONG UNITED STATES DOCTORATE-LEVEL SCIENTISTS, ENGINEERS, AND SCHOLARS, 1973

Highlights

Two sources of data within the Commission on Human Resources of the National Research Council were used to determine the numbers of minority group members in the doctorate-level population of the United States. The first source, which includes all fields of study, shows the number of people earning third-level degrees (PhD, ScD, EdD, etc., but excluding such professional degrees as MD, DDS and DVM) from U.S. universities in the academic year 1972-73. The second source, which is restricted to doctorate-level engineers and scientists, including social scientists, consists of a large and carefully-stratified sample of the entire current (1973) labor force at this level. The highlights of the findings from analysis of these two data sources are given below. However, because of the complexities of definitions, techniques, and coverage, the reader is urged to examine the full report in order to achieve a more exact interpretation of the findings highlighted below.

- In 1973, approximately 4000 members of minority groups attained doctoral degrees (PhD, ScD, EdD, etc., but excluding MD, DVM, DDS and other professional degrees) in United States universities. This included approximately 975 Blacks, 2430 Orientals, 350 Latins and 150 American Indians. Of this total, 37%, or approximately 1470, were United States citizens, 1160 were non-U.S. citizens but held immigration visas, and the rest were non-U.S. citizens holding other types of visas.
- Racial/ethnic groups vary by discipline among the 1973 doctorate recipients. Blacks and American Indians are heavily concentrated in education, and Orientals in the natural sciences, as compared with the field distribution among White Americans.

- Even allowing for the differing discipline requirements of the various categories of employers, a pattern of variation is evident in plans for employment: Blacks enter educational institutions in higher proportions than other employment, Orientals enter business and industry disproportionately, while data on the other minority groups show less clear-cut patterns.

- A careful sampling survey of doctorate-level scientists and engineers actually in the 1973 labor force--as distinguished from the graduates of 1973--shows that within this technical group there were approximately 1,860 Blacks, approximately 11,000 Orientals, 1,400 Latins, 100 American Indians, and 300 members of all other minority groups, including mixtures. Of these people, approximately 28% were U.S. native citizens.

- This scientific and engineering population was analyzed in terms of period of graduation, to furnish an approximation to growth rate data. This showed an increase in minority-group members in this group that has been more rapid than the increase of the White majority, but these rates of increase have come principally from the "brain drain" from foreign countries, rather than from the U.S. native population, in which the minority-group rates of increase are, with one exception, lower than that for Whites.

MINORITY GROUPS AMONG DOCTORATE-LEVEL SCIENTISTS, ENGINEERS, AND SCHOLARS IN THE UNITED STATES, 1973

Introduction

What are the numbers of people who are members of minority groups, among doctorate-level scientists, engineers, and scholars in the United States? This question has become particularly important in recent years, with efforts to achieve equal employment opportunity for minority group members within our society. This report seeks to present the most authoritative data presently available with respect to these questions, as of 1973. These data are, in the opinion of the Commission on Human Resources, more reliable than previous estimates made on the basis of analysis of educational backgrounds or Spanish surnames, or ad hoc surveys conducted at a limited number of universities--which were the only methods available for surveys of these groups at the doctorate level until very recently. Throughout this report the term "PhD" will be used as a kind of shorthand for third-level degrees, including PhD, ScD, EdD, but excluding such professional degrees as MD, DVM and DDS.

Earlier studies, such as those by Conyers (1968), Crossland (1968), Wispe et al (1969), Bryan (1970), Jay (1971) and Harvey (1972) have provided useful data.(1) However, they did not have available such extensive survey opportunities as those afforded by the Doctorate Records File and the Comprehensive Roster of Doctorate Scientists and Engineers, both of which are maintained by the Commission on Human Resources (CHR) of the National Research Council, with sponsorship by several government agencies. The nature and limitations of these two sources are described below. Their differences are important to keep in mind, as two quite different sets of data emerge. The Doctorate Records File provides data on current graduates in all fields; the Comprehensive Roster provides labor force data, but only with respect to the fields of science and engineering. A number of other studies have recently been made, or are under way, and these will be reviewed in a publication of the National Board on Graduate Education, planned for the spring of 1975. Among these are studies by the American Council on Education, the American Institute of Physics, the Scientific Manpower Commission, and the Engineering Manpower Commission.

(1) See bibliography, page 42.

The Doctorate Records File

The Doctorate Records File (DRF) contains data on all PhD's granted by U.S. universities from 1920 to the present. It is maintained continually by the CHR, under sponsorship of four government agencies--the National Science Foundation, the Office of Education, the National Endowment for the Humanities, and the National Institutes of Health. The cooperation of the graduate deans of all the PhD-granting institutions has made possible the completion, by each new PhD-level graduate, of a questionnaire in the annual Survey of Earned Doctorates. These forms are sent to the CHR, where the basic data bank is maintained. It is available for statistical information only; individual data are held strictly confidential. The procedure involving the Survey of Earned Doctorates questionnaire has been in use since 1957; data for earlier years were obtained from graduation announcements and lists compiled by the graduate schools. Prior to fiscal year 1973 (July 1972-June 1973) the Survey of Earned Doctorates contained no information on racial or ethnic origin. Beginning in FY 1973, however, an item (described later) was included, and this item provides the first accurate information available on the racial/ethnic origins of U.S. PhD's. The DRF contains data on all disciplines--the sciences and engineering, mathematics, arts and humanities and professional fields, including education.

The Comprehensive Roster

The second source of reliable data is the Comprehensive Roster of Doctoral Scientists and Engineers,[1] also compiled and maintained by the CHR. This roster, which is designed to include the entire U.S. labor force at the PhD level in the fields of science and engineering, was derived from several sources, principally the DRF described above. However, PhD-level graduates of foreign universities were included to the extent that they could be identified through American Men and Women of Science, college and

(1) Maintained under the sponsorship of the National Science Foundation

university catalogs, or the National Register of Scientific and Technical Personnel. The Register, long maintained by the National Science Foundation, was discontinued in 1970, and the Comprehensive Roster is one part of a replacement data system. In general, a 1-in-6 sample was used, but this was augmented to a minimum of 1-in-4 in the biosciences. This augmentation was designed to obtain a heavier sample in the health-related fields. A biennial survey of a stratified sample systematically drawn from this Roster provides the data used as the second source in the present report. The sample was carefully selected by sex, field, graduation cohort, and size of institution of PhD, so that it would faithfully reproduce the entire population from which it was drawn. Race and ethnic identification items on the questionnaire used in the 1973 survey give a cross-sectional picture of the relevant labor force, which, however, is limited to scientists (including social scientists, mathematicians, and engineers). It does not include scholars in the arts and humanities, education, or such professions as journalism, social work, law, religion, and business administration.

Data from these two sources are presented separately in this report, followed by an attempt to show the extent to which these sources agree. First, however, some general matters of technique and definition must be dealt with because so much depends on what questions are asked, how they are asked, and of what population groups.

An Historical Note

For many years, Federal regulations prevented the collection of information that would identify individuals by race or ethnic group. The objective, to prevent discrimination, also prevented the accumulation of statistical data. This forced recourse to various techniques and procedures that, it was hoped, would correlate sufficiently with actual racial or ethnic identification to permit statistical results to be achieved, with full recognition of the fact that errors in individual cases would occur, and that the results would have statistical utility only. Some

data, shown in Appendix 1, were obtained by these indirect techniques. They have severe limitations, if one accepts self-designation as the criterion. In this report, the latter technique is the accepted one, and all of the data, with the exception of those in Appendix 1, are based on such self-designations. Even here, it should be noted, there are limitations, as some people decline to answer a question in this area. The absence of useable self-designations in about 7.7% of the cases required a correction, as described in Appendix 2.

Definitions and Operational Procedures

The definitions employed in this report lack the precision of those of an anthropologist or sociologist; they are approximations adapted to the present reality of the need for data to guide policy in a practical employment situation. They are therefore relatively simple, and rely on self-designations of persons at the PhD level as to their inclusion in one or more of several racial/ethnic categories.

The term racial/ethnic is used in recognition of the fact that we lack clear distinctions among social groups for whom our society uses such labels. Races are mixed and ethnic identifications may cross racial lines. Empirically, however, it was found in the present study that this occurred only infrequently, so that, however important these distinctions may be in individual cases, the statistical picture is not seriously blurred. People in the surveys here reported tend to identify themselves, with a small margin of uncertainty or non-response, as belonging in one or another of the groups identified as follows:

White/Caucasian
Black/Negro/Afro-American
American Indian
Spanish-American/Mexican-American/Chicano
Puerto Rican-American
Oriental
Other (specify) _____

Results from the 1973 Survey of Earned Doctorates

In the 1973 Survey of Earned Doctorates, a new form of questionnaire was employed, which contained, for the first time, an item relating to racial/ethnic identification. Because earlier forms of the questionnaire were still available and were used in some universities, it turned out that only about 80% of the new PhD's responded on the questionnaire which contained the racial/ethnic item. It appears, however, that no bias was introduced by this accident. For some of the tables reported below, a correction factor has been employed to estimate the total numbers in each of the minority groups that would have been found if all the 1973 graduates had filled out the newer Doctorate Survey form.(1) In other tables, only the cases actually responding to the racial/ethnic item will be included, or, in other cases, those responding to this item plus one other, where cross-tabulations are involved.

Table 1 reports the numbers (with appropriate blow-up for sampling and response as described above) in each group, including the predominant White/Caucasian group, by citizenship status. Because of the blow-up for the cases of persons who did not have an opportunity to respond to the racial/ethnic item, the numbers shown in Table 1 will not agree with some of the analytical tables to follow, which include only the cases where racial/ethnic status was actually stated.

In spite of this blow-up to compensate for incomplete data, these figures are highly accurate because they come so near to being "census" data which, by definition, do not have sampling errors. Because the small proportion (about 10%) who did not respond when they had the opportunity cannot be assessed in terms of the amount or direction of possible bias, they are combined with the much larger group who had no opportunity to respond to the racial/ethnic question, for assessment of possible errors in the figures of Table 1. For the smallest groups (N=17-63) the figures shown are subject to an error of 5% to 10%. For the next larger set (N=105-347) the error estimate drops to between 2% and 4%. For the next set (N=587-2429) the error is between 1% and 2%. For the majority White U.S. citizen group the error is only .1%. See Appendix 2 for further detail.

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(1) See Appendix 2 on page 37.

Table 1

Number Receiving PhD's in 1973, by Citizenship and Racial/Ethnic Identification (Data Corrected for Partial Response)*

Citizenship	White Caucasian	(1) Black	(2) Oriental	(3) Latin	(4) American Indian	All Other	Minority Total	GRAND TOTAL
U.S. Citizens	26,400	760	320	228	148	12	1,468	27,868
Non-U.S. Cit. Immigr. Visa	826	56	1,067	23	0	12	1,158	1,984
Non-U.S. Cit. Other Visas	1,817	160	1,042	96	1	46	1,345	3,162
TOTAL KNOWN	29,043	976	2,429	347	149	70	3,971	33,014
Citizenship & Ethnicity unknown	--	--	--	--	--	--	--	713
TOTAL	29,043	976	2,429	347	149	70	3,971	33,727

(1) Includes 12 individuals who indicate White, Indian, or other mixtures.
(2) Includes South Asians, to the extent these people so identified themselves.
(3) Includes Puerto Ricans, Spanish-Americans and Mexican-Americans.
(4) Includes 19% who checked only this category; 81% checked American Indian and White.

* See Appendix 2 for details on procedure.

The data of Table 1 are portrayed graphically in Figure 1, except that the racial/ethnic status is there reduced to a dichotomy of White/Caucasian vs. all other. In Figure 2, the details on minority racial/ethnic status are shown for each of the citizenship groups. In both of these figures, the numbers of cases within each category are indicated by the area on the graph. Figure 1 shows at a glance the overwhelming White/Caucasian composition of the U.S. citizen group. For the foreign citizen categories, there is a more nearly even balance. In Figure 2 it is apparent that, for the U.S. citizens, Blacks are the dominant group, Orientals second, Latins third, and American Indians fourth, with a tiny "all other" group. Those in the non-U.S. citizen category are predominantly Oriental, with small groups in the Black, Latin and "all other" categories.

In Table 1 and Figure 2 one notes that practically all the American Indians are U.S. citizens, as are over three-fourths of the Blacks and two-thirds of the Latin group, but only 13% of the Orientals and 18% of the small "all other" group. When one tries to translate these figures into data on the U.S. labor force, it is necessary to make assumptions about how many of these graduates will remain in the United States. The post-graduation

Figure 1

1973 PhD's, by Citizenship, Divided into White/Caucasian and All Other Categories

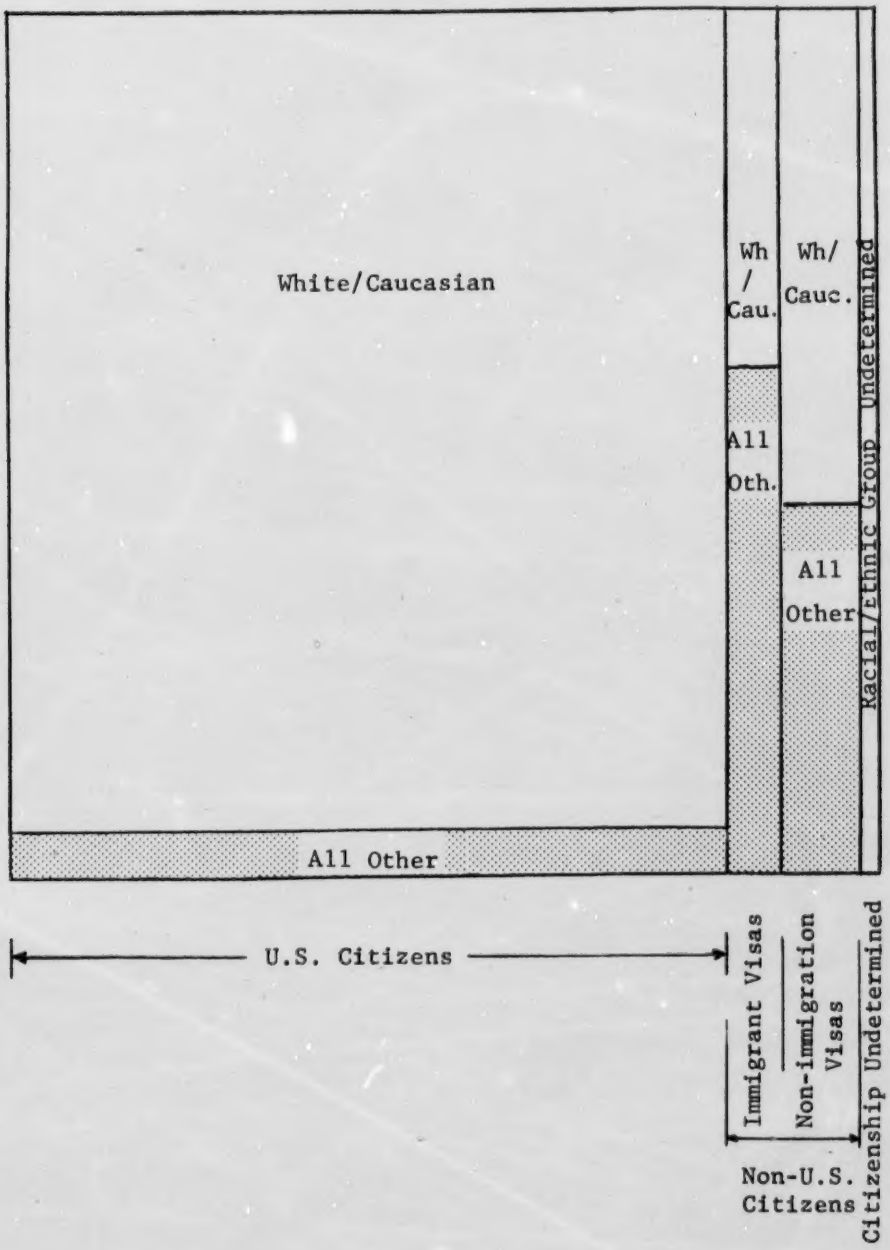
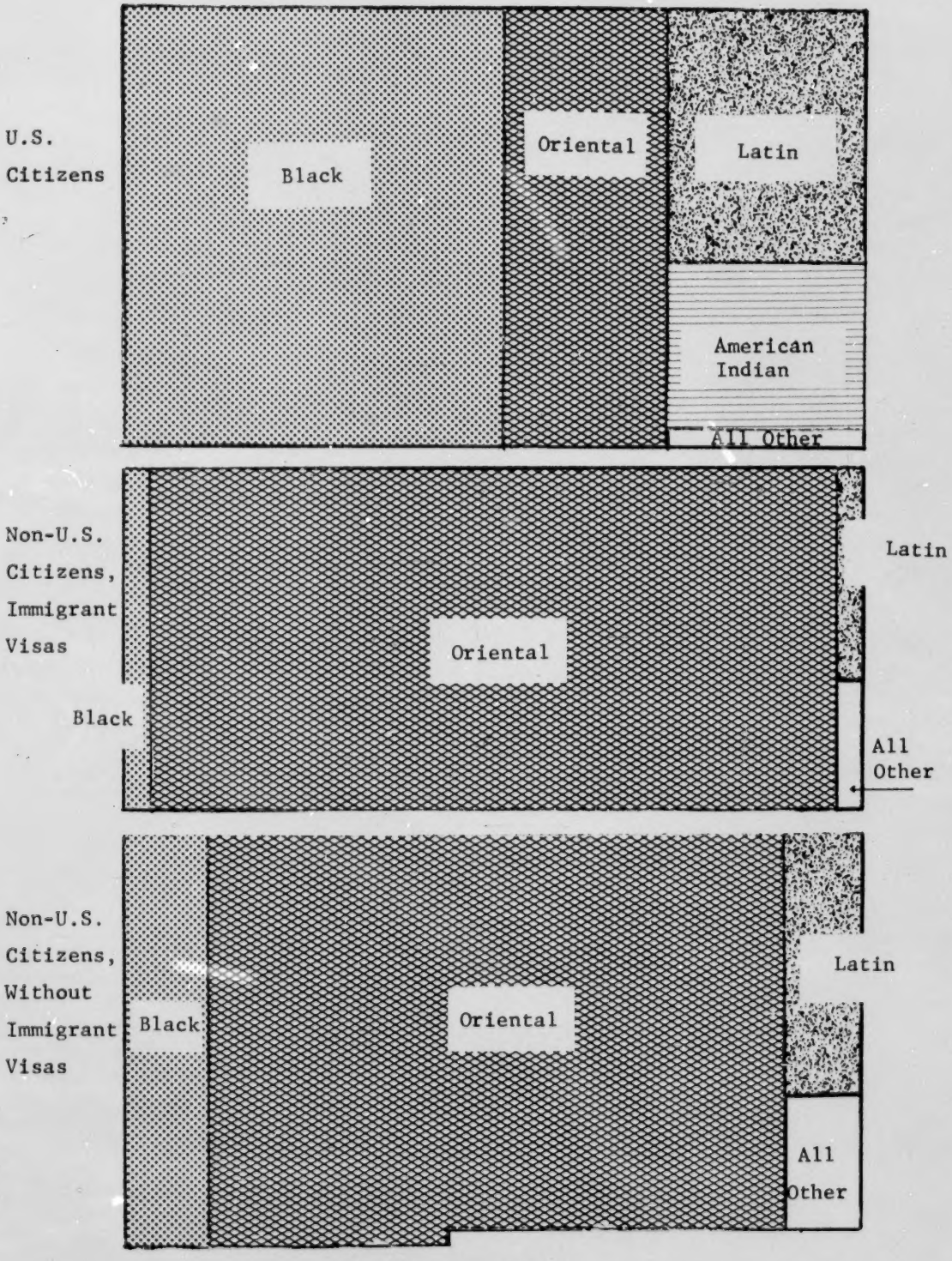


Figure 2

Minority Groups by Citizenship Status, 1973 PhD's



plans of a substantial number of the foreign citizens are uncertain. For purposes of statistical estimation, one may assume that all the U.S. citizens will remain in the country, as well as the non-U.S. citizens who hold immigration visas--i.e., one may combine the first two rows of Table 1. One may make the further assumption, for the purpose of this estimation, that all temporary-visa foreign-citizen PhD's leave the country. While neither of these assumptions is strictly true, it is not unreasonable to suppose that their errors approximately cancel out. When this is done, one obtains the data of Table 2, as descriptive of the probable additions to the U.S. labor force contributed by the 1973 PhD graduates. The accuracy of these figures given the above assumptions is discussed in Appendix 2.

Table 2

Estimated Proportions of Racial/Ethnic Groups Added to U.S. Labor Force from 1973 PhD Graduates (U.S. Citizens + Immigrant Visa Cases)*

Racial-Ethnic Group	Number of Cases	Percentage of Total	% Distribution Within Minority Group
White	27,226	91.2	
Black	816	2.7	31.3
Oriental	1,387	4.6	52.8
Latin	251	.8	9.6
American Indian	148	.5	5.6
All Other Minorities	24	.1	.9
Minority Total	2,626	8.8	100.0
GRAND TOTAL (Excluding unknown and non-U.S. citizens)	29,852	100.0	-----

* The error of these percentages in column 2 is less than .1%. In column 3 the standard error is less than 1.0% for Blacks and Orientals and less than .6% for Latins and Indians.

Distribution by Discipline

Members of these minority groups are not distributed through the various disciplines in equal proportions, nor in proportions resembling those of the majority White population. This fact is of vital significance with respect to recruitment of minority personnel for work in the several disciplines, and thus affects their employment among the various employing groups. Business and industry, for example, employ proportionately more chemists and engineers than do other employing groups, such as academic institutions, government, and non-profit organizations. The percentage distribution of the various racial/ethnic groups, including White, by field and citizenship category, is given in Table 3. The error range in Table 3, as in Table 1, varies with group size. For the smallest group (Latins with immigration visas) it varies from 3% to 5%. For most groups, ranging in size from 160 to 1817, the standard error of the percentages shown ranges from .25% to 2%. For the White U.S. citizen group, of course, it is much less--about .1%. Appendix 2 gives further data on reliabilities of these group differences.

In examining Table 3, it is apparent that, within each of the three citizenship categories, the field distribution of each racial/ethnic group is different, and that for each racial/ethnic group, the field distribution varies by citizenship. These variations are statistically significant. As mentioned earlier, this induces a further effect on the distribution across employer categories. The latter, however, are not purely a function of the varying disciplinary requirements of the several employer categories. There are other factors, which cannot be ascertained from the data at hand, which apparently affect employer category distribution.

Table 3

Percentage Distribution of Racial/Ethnic Groups by Field, by Citizenship Categories among 1973 Doctorate Recipients

Racial/Ethnic Group	Engin, Math & Phys Sci	Life Sciences	Psych-ology	Social Sciences	Human-ities & Arts	Professions	Education	TOTAL ALL FIELDS
			U.S. Citizens					
White	22.8	14.1	8.3	10.0	17.7	4.3	22.8	100.0
Black	8.6	9.0	3.9	6.5	9.4	3.1	59.5	100.0
Oriental	42.1	24.3	5.7	10.5	8.1	3.2	6.1	100.0
Latin	14.8	15.9	9.1	8.5	26.7	.6	24.4	100.0
American Indian	15.8	14.9	8.8	10.5	18.4	.9	30.7	100.0
TOTAL	22.1	14.2	8.2	9.8	17.1	4.3	24.2	100.0
			Non-U.S. Citizens with Immigrant Visas					
White	35.1	16.1	4.8	10.5	23.1	2.7	7.5	100.0
Black	7.3	26.8	0.0	12.2	24.4	4.9	22.0	100.0
Oriental	62.0	21.1	1.2	7.2	3.5	2.1	3.0	100.0
Latin	29.4	5.9	0.0	0.0	47.1	5.9	11.8	100.0
TOTAL	49.1	18.7	2.5	9.6	11.5	3.2	5.3	100.0
			Non-U.S. Citizens with Other Types of Visas					
White	36.3	17.6	3.9	15.1	10.8	6.6	9.4	100.0
Black	16.2	30.5	1.0	20.8	9.5	3.8	19.0	100.0
Oriental	52.5	20.9	1.0	10.8	5.3	1.5	7.9	100.0
Latin	41.3	42.0	0.0	4.8	3.2	3.2	4.8	100.0
TOTAL	41.4	20.5	2.5	14.1	7.8	4.7	9.1	100.0

Table 4

Percentage Distribution of Employer Categories by Field, 1973 Doctorates, U. S. Citizens Only

Type of Employer	Engin, Math & Phys Sci	Life Sciences	Psych-ology	Social Sciences	Human-ities & Arts	Profes-sions	Educa-tion	TOTAL ALL FIELDS
Educ. Institutions (All levels)	27.5	33.5	43.8	70.3	79.2	70.1	76.0	56.2
U.S. Government	12.1	8.2	18.0	7.6	1.4	6.8	8.7	8.7
Industry & Business	25.4	7.7	3.5	3.5	1.1	4.9	1.1	8.1
Non-Profit Organ.	1.7	2.3	10.5	4.0	1.8	8.1	3.9	3.5
All Other Known Types	3.3	4.6	3.6	5.1	3.8	3.1	1.8	3.4
Postdoctoral Training & Employer Unknown	30.0	43.7	20.6	9.5	12.7	7.0	8.5	20.0
	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0

The extent to which people in each field distribute themselves across employer categories may be estimated from plans at PhD as reported in the Survey of Earned Doctorates. These data are shown in Table 4 for all racial/ethnic groups combined, but including only U.S. citizens, in order to eliminate any further effects that citizenship might exert on the results. These percentages can then be used to determine the proportion of each racial/ethnic group that would be expected to be found in each employer category if only field differences determined the employer category distribution. To do this, the total number in each field for each racial/ethnic group is multiplied by the appropriate decimal fraction in Table 4. The resulting numbers are summed for each employer category to derive the "expected value". This expected value is then compared with the actual number found in the given employer category for each of the racial/ethnic groups, and a set of "frequency discordance" values are obtained. This frequency discordance value, squared, is then divided by the expected value to derive what is known as the X^2 (Chi Square) value for that cell. These X^2 values are summed for each of the racial/ethnic groups to determine whether the frequency discordances actually observed are greater than would be expected on the basis of random sampling variations alone. They can also be summed for any set of

racial/ethnic categories--e.g., for all the minorities, to determine whether the differences found are greater than would be expected on a random-sampling basis. The frequency discordances thus observed, and the resulting X^2 values, are given in Table 5. The degree of confidence one may place in these discrepancy values is indicated by the X^2 value at the bottom of each column and by the total X^2 of 32.2, which is significant beyond the 5% level as are the values for the Black and Oriental columns individually. The other columns are not individually significant in their discrepancy patterns.

Table 5

Actual Employer Category Distribution for Each Racial/Ethnic Group, Compared to Expected Distribution, for 1973 Doctorate Recipients, U.S. Citizens Only

Employer Category		White	Black	Oriental	Latin	American Indian	Total*
Educational Institutions	Actual N	11,429	416	83	100	70	12,098
	Expected N	11,429	390	106	105	67	12,098
	Difference	000	+26	-23	-5	+3	
US Government	Actual N	1,786	43	24	14	7	1,874
	Expected N	1,772	50	24	14	10	1,870
	Difference	+14	-7	0	0	-3	
Business & Industry	Actual N	1,674	16	39	10	6	1,745
	Expected N	1,665	25	33	11	7	1,741
	Difference	+9	-9	+6	-1	-1	
Non-Profit Organizations	Actual N	726	16	5	7	8	762
	Expected N	722	22	6	6	4	760
	Difference	+4	-6	-1	+1	+4	
All Other Known Types	Actual N	710	7	9	5	5	736
	Expected N	699	16	9	6	4	734
	Difference	+11	-9	0	-1	+1	
Postdoctorals & Unknown	Actual N	4,077	89	87	40	18	4,311
	Expected N	4,103	85	67	35	22	4,312
	Difference	-26	+4	+20	+5	-4	
TOTAL, ALL CATEGORIES		20,402	587	247	176	114	21,526
X^2 (Chi Square)		.5	12.5	12.0	1.6	5.6	32.2

There are 20 degrees of freedom; the probability level = .05

* The discrepancies between actual and expected values in the Total column are due to rounding errors in calculating expected values.

In examining Table 5, it is important to remember that the frequency discordances shown there are those that remain after holding constant the effects of citizenship and the field variations of the various racial/ethnic groups. The final column at the right should show no frequency discordances. Those that are shown are the result of rounding errors--i.e., the expected values are given in whole numbers, whereas the calculated values include decimal fractions which do not always cancel out. The important values are those in the columns for the various minority groups; the expected numbers in the column for Whites show only insignificant variations from the actual values, simply because the White population is the overwhelming majority of the total group used to determine the expected values.

In the Black column in Table 5, there is an unexpectedly large proportion within the category of educational institutions, which includes all levels, but is predominantly colleges and universities. All other employer categories are below expectation. In the Oriental column, there are more than expected in the postdoctoral and unknown category (primarily postdoctorals) and in the business and industry category; others, including educational institutions are below expectation. The same pattern, except for business and industry, holds for the Latin group, but the numbers are few, and the results correspondingly unreliable. The American Indians are found in somewhat greater than expected frequency in educational institutions and non-profit organizations, but for this group, as the Latins, the numbers are not large enough to provide great confidence in the resulting pattern. For each of the racial/ethnic groups, the sum of the X^2 values is found at the bottom of the column; these values, summed across the whole table come to 32.2, which is statistically significant at the .05 level. In other words, there is only one chance in 20 that results as discordant as these would be found through random sampling alone. Inasmuch as the statistics are based essentially on population values, rather than a sample, the "random sampling" concept cannot strictly apply. However, one could think of the 1973 graduates as a sample from a series of years, and this line of reasoning would indicate the improbability of these findings being reversed if one had similar data for 1972; one can reasonably expect a replication when the 1974 data are available, although these "annual samples" are of a systematic nature, rather than random, and may be expected to change gradually over time, preferably in a direction which would reduce the X^2 values toward the zero point.

Results from the Comprehensive Roster of Doctoral Scientists and Engineers

The data discussed up to this point have come from the annual Survey of Earned Doctorates, specifically the PhD graduates of 1973. Data with respect to the numbers of people, including minority groups, in the U.S. labor force at the PhD level, with respect to science and engineering fields, are available from the Comprehensive Roster of Doctoral Scientists and Engineers, as mentioned earlier. The data reported below were collected from a sampling survey in 1973. From the dates of PhD graduations, we can infer or make estimates of how rapidly they have been coming into the labor force. This will yield growth rate figures that may be compared with the actual input figures previously reported from the Survey of Earned Doctorates, and give some basis for projections over the next few years.

It is important to recognize, in examining the Comprehensive Roster data, that these people comprise not only U.S. PhD's, but also those who have come to the United States after earning doctorates abroad. They include some who have earned their doctorates in the arts, the humanities, and the professions, including education, but who have switched to science or engineering fields subsequent to graduation. It includes some who have earned science and engineering PhD's but who have subsequently moved into positions in administration, or elsewhere, and who have classified themselves as "not in science". However, as they have the basic background for scientific and/or engineering work, they have been retained in the survey, and are included in the data given below.

In the Comprehensive Roster questionnaire, a different form of item was used with regard to racial and ethnic group identification than was used in the Survey of Earned Doctorates. There were, in fact, two separate items, one relating to race, and one relating to ethnic identification. The items were as follows:

Race: (Please check one)

0 White/Caucasian 1 Black/Negro 2 American Indian

3 Asian, specify _____ 4 Other, specify _____

Ethnic Group: (Please check one)

0 Puerto Rican American 1 Mexican American/Chicano

2 Spanish American 3 Afro-American 4 None of these

(Please specify any other) _____

The response to the race item was 91.6%, but to the ethnic group item only 70%. Because of the stricture to check only one item, those of mixed racial ancestry are not reported as fully as is possible on the Doctorate Survey item. For example, in the Doctorate Survey, over 80% of the American Indians also checked "White"; this leads to problems of comparability which will be discussed in more detail later. In order to derive statistics as nearly comparable as possible to those of the Survey of Earned Doctorates, Ethnic Group responses coded 0, 1 and 2 were combined to yield a "Latin" total. The "Black" total was derived by including all persons who checked either "Afro-American" for ethnic group or "Black/ Negro" for race.

In what follows, we shall examine first the growth in total numbers for the minorities in this doctoral science/engineering group as a whole, then the growth of these numbers by citizenship or origins categories, and later consider their fields of specialization, their employer categories and major work activities. Data are given by five-year periods of graduation, beginning in 1934, with the exception of the most recent period, which includes only fiscal years 1970, 71 and 72.

Table 6 presents data for all citizenship categories, broken out by racial/ethnic groups, with a summation of all the minority groups, and also gives, for a basis of comparison, the U.S. total data by five-year intervals. The minority percentage has increased greatly since the 1930's. Since the end of the "GI bulge" in the early and mid-1950's, this increase has been steady. This minority increase is due largely to foreign PhD's, and U.S. PhD's of foreign origin. The drop in the minority-group percentage in the 1970-72 period was due to the fact that coverage of the foreign PhD group was not as effective for this period, as there had not been time enough for them to get listed in the standard compendia that were used as sources for this group, such as American Men and Women of Science.

As the bottom line shows, there are 244,829 doctoral scientists and engineers in total in this group, and of these, 14,663 (6%) are members of the various minority groups. Of the latter, the Orientals are by far the largest, with 10,987 members, or 75% of all minority-group members. Blacks, with 1,860, come next, comprising 12.7%, with Latins third with 1,412 or 9.6%.

Table 6

Racial/Ethnic Groups Identified in the Comprehensive Roster of Doctoral Scientists and Engineers, by Fiscal Year of Doctorate

Period of PhD Graduation	U. S. Total	All Minorities N	%	Racial/Ethnic Group Black	Oriental	Latin	American Indian	Other
1930-34	5,750	89	1.7	18	59	12	0	0
1935-39	7,335	110	1.5	39	49	22	0	0
1940-44	8,768	189	2.2	51	100	36	0	2
1945-49	9,889	441	4.5	118	234	73	0	16
1950-54	25,482	886	3.5	156	612	95	12	11
1955-59	27,909	1,265	4.5	270	829	111	18	32
1960-64	39,423	2,582	6.5	257	2,007	253	21	44
1965-69	66,795	5,365	8.0	508	4,275	431	30	121
1970-72	53,478	3,736	7.0*	443	2,822	374	25	72
TOTAL	244,829	14,663	6.0	1,860	10,987	1,412	106	298

* See text. This drop from 1965-69 was probably due to poorer coverage of foreign doctorate holders in the 1970-72 cohort.

American Indians, with only 106 cases, are the smallest group here distinguished, comprising .7% of the minority total.(1) Miscellaneous other groups, including mixtures of racial and ethnic items, comprise 298 cases, or 2% of the minority total. It is noteworthy that the minority groups, with the exception of the American Indian component, have been growing at a more rapid rate than has the entire science/engineering population. As mentioned earlier, the item on the Comprehensive Roster survey was not directly comparable to that of the Survey of Earned Doctorates with respect to this particular group. It is quite possible that, had the item on the Comprehensive Roster survey provided the multiple-checking option, the American Indian component would have been much larger, and possibly had a different growth rate. The relative growth rates of the several groups in the Comprehensive Roster survey are shown in Figure 3.(2)

(1) See Appendix 2 for a treatment of the accuracy of these percentages.

(2) 1973 Doctorate Survey data have been added, as shown by dotted lines. The derivation of these data, and their significance, is discussed on page 24.

Figure 3

Racial/Ethnic Groups in the 1973 Comprehensive Roster of Doctoral Scientists and Engineers, All Citizenship Groups Combined by Fiscal Year of Doctorate (and '73 DRF)

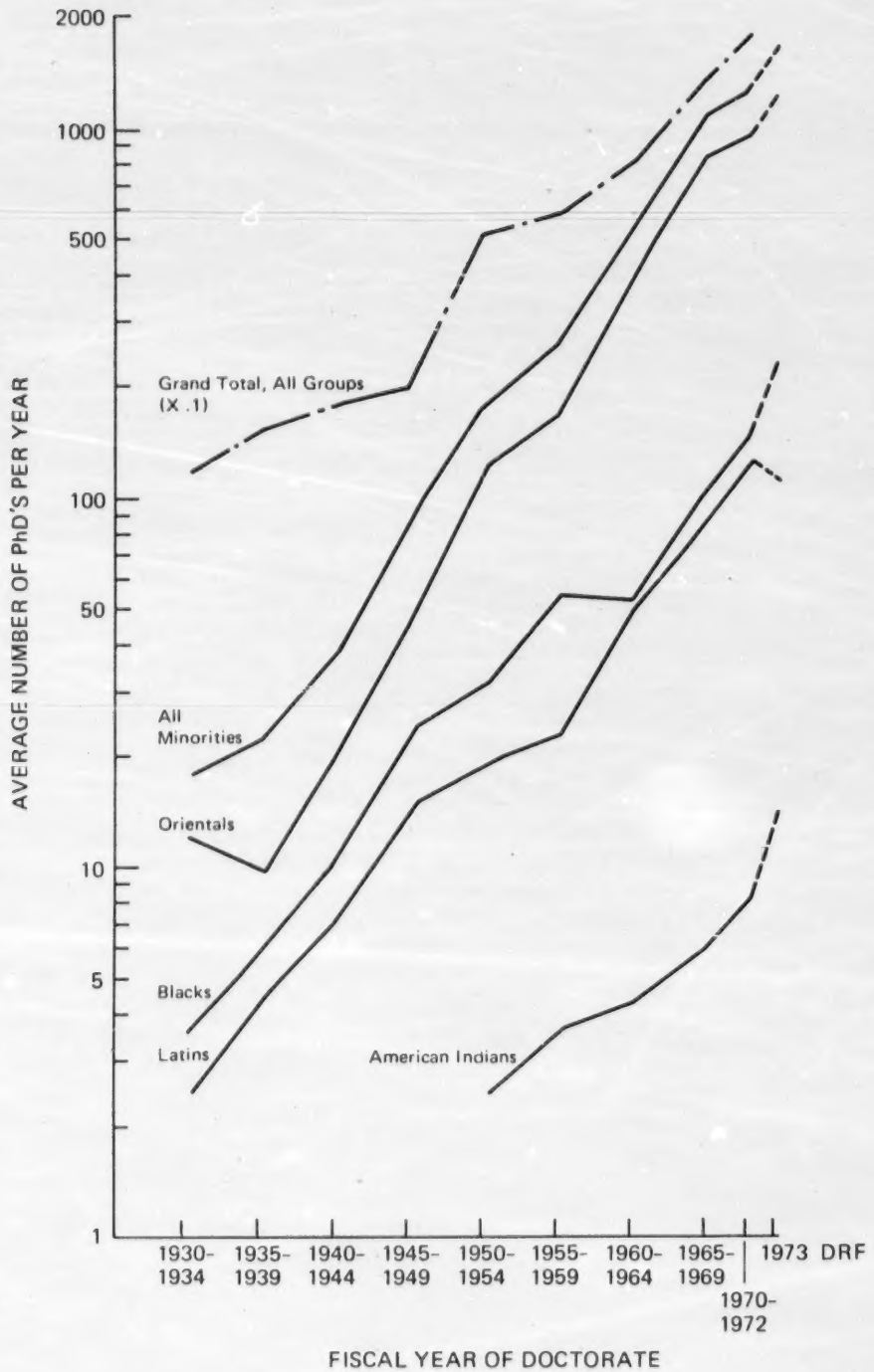


Figure 3 is plotted on semilog paper, as this has the effect of transforming an exponential growth curve (typical of this set) into straight lines, the slope of the curve being related to the rate of exponential growth. Figure 3 shows average annual growth for each period shown in Table 6, with the exception that the U.S. total figures are plotted at 1/10 of their actual value, in order to make the curve closer to that of the minority groups for better comparison. It is clear that taking the graduation periods for those in the labor force at any given time (1973 in this case) yields only an approximation to a growth curve, as some of those who graduated earlier have left, through death or retirement or otherwise. But the error in this case is small, it was discovered, by comparing this curve with one (not shown here) for actual U.S. PhD output in these fields over the same period. For the period 1930-1945 there was a slight difference, probably because of deaths in these earlier cohorts. Then the curves coincide, until the most recent decade, where a slight divergence apparently reflects emigration of non-U.S. citizens earning U.S. doctorates. It is clear that the minority growth curves are mostly steeper than the growth curve for the total. The computed average annual growth rate for the total population here concerned is 7.9% per year, while the minority component has grown at an average annual rate of 11.9%. In the period since World War II, this disparity in growth curves has decreased, the overall average annual rate being 10.2% and for the minority 11.8%. The minorities component as a percentage of the overall total has increased from 1.5% in the 1930's to about 4.5% in the fifteen years following World War II and about 7% to 8% in the most recent years.

Within the minorities group, the several components have not increased at an equal rate. The Orientals, comprising 75% of the minority total, have experienced an average annual growth of 13.2% and 14% for the period since WWII. This group is about 90% foreign-born, whereas the next largest group, the Blacks, are 90% native U.S. citizens. The Black growth rate has averaged 10.5% per year from 1930, but only 8.3% since WWII. The Latin group, the third largest of the minorities, has had a growth rate of 10.7% over the 43-year period, and 9.5% since WWII. This group is 60% U.S.

natives and 40% foreign-born. These figures give some indication of the importance of the "brain drain", particularly with respect to minority groups. A separate look at the native-born citizen group, and its minority components, will be useful in assessing this question.

Table 7

Native-Born U.S. Citizens in the Comprehensive Roster, Showing Minority Racial/Ethnic Groups, by Fiscal Year of Doctorate

Period of PhD Graduation	US Native Citizens		US Native Racial/Ethnic Minorities					All Minorities	
	Number	% of All-Cit Total	Black	Oriental	Latin	American Indian	Other	Number	% of Native Total
1930-34	4,718	82.1	18	26	9	0	0	53	1.1
1935-39	6,134	83.6	28	0	11	0	0	39	0.6
1940-44	7,805	89.0	56	15	23	0	0	84	1.1
1945-49	8,287	83.8	118	88	31	0	16	253	3.1
1950-54	21,681	85.1	141	99	71	12	0	323	1.5
1955-59	23,577	84.5	233	136	65	18	18	470	2.0
1960-64	32,766	83.1	250	224	159	21	35	689	2.1
1965-69	56,470	84.5	459	338	291	25	104	1,217	2.2
1970-72	46,941	87.8	384	212	230	25	58	909	1.9
TOTAL	208,379	85.1	1,677	1,138	890	101	231	4,037	1.9

Table 7 provides the data on native-born U.S. citizens by racial/ethnic group. The native citizens have remained a relatively constant proportion of the total, as judged by the years of PhD graduation, over the whole time span shown here. The percentage has varied from a low of 82-84% in the 1930's to a high of about 89% during the World War II period and 88% for the 1970-72 period. The high for 1970-72 probably reflects the difficulty in locating, for survey purposes, people who have recently immigrated, as they would not yet be in the reference sources used to compile the Comprehensive Roster, unless they took United States doctorates. The overall percentage for U.S. native citizens is 85% for all graduation cohorts. Among the minorities, the total for Blacks is not much lower than in Table 6, and the American Indian total is lower by only five cases. The "Other" group is also not changed much, possibly reflecting the mixture of races in the American native population.

Growth rates for the minority groups are not particularly stable over the earlier cohorts, primarily because the numbers of cases were so small as to make for unreliability of the sampling statistics. For the period since World War II, however, the numbers are larger and are reasonably reliable. For this period, the growth rate for the native minorities, except for the Latin contingent, have been lower than for the U.S. total. Average annual growth rates, from 1930 to 1972 for the data of Table 7 are as follows:

U.S. Citizens - Native Born

U.S. Total.....	10.5%
Minorities Total.....	7.5%
Blacks.....	7.4%
Orientals.....	6.0%
Latins.....	12.0%
American Indians.....	6.7% since 1950 (first data)

As can be seen by the column at the extreme right of Table 7, the minority groups identified in this survey have averaged only 1.9% of the total. With the exception of the immediate post-World War II period, this proportion has never exceeded 2.2%. This compares with minority percentages ranging from 2.2% to 8.0% over the last 30 years for all citizenship groups combined, as shown in Table 6.

Comparison of Comprehensive Roster and 1973 DRF Data

Because data for this report were drawn from two quite different sources, which are not comparable in coverage, a complete cross-check is not possible. It should be possible, however, to determine the degree of compatibility, within reasonable limits, given a set of explicit assumptions. The assumptions used to compare the data (on scientific and engineering fields only) include those on page 8 relating to potential additions to the U.S. labor force as given in Table 2. With this caveat, it is possible to determine

whether these two data sets give reasonably compatible or grossly different estimates of minority groups within the scientific and engineering fields at the doctorate level. This was done by plotting data derived in the same manner as for Table 2 or Figure 3, where they could be visually compared with the "quasi-growth curves" previously plotted.

In Figure 3, dotted lines have been added which extend each curve from the 1970-72 data point for the Comprehensive Roster data to a 1973 data point which represents an estimate of 1973 data from the Doctorate Records File. In considering these additions, it is important to keep in mind a special condition which applies particularly to the American Indian group. It will be recalled that, in the 1973 Survey of Earned Doctorates, an option was provided whereby a person could indicate mixed ancestry by checking more than one alternative. As noted earlier, 80% of the American Indians in the Doctorate Survey also classified themselves as White/Caucasian. In the Comprehensive Roster survey, the multiple-classification option was not available; to make the data as nearly comparable as possible, only those who indicated "American Indian" as their only category on the 1973 Doctorate Survey have been included in the data plotted in Figure 3 and shown below:

Minority Groups in the
1973 Survey of Earned Doctorates

Blacks	238	
Orientals	1249	
Latins	117	
American Indians	73	(including White mixtures)
American Indians	14	(including "Indian" only)

These data have been derived in the same manner as those shown in Table 2, on page 11, except that only the science and engineering fields are included. It will be remembered that these figures, derived to estimate additions to the U.S. labor force, included only United States citizens and non-U.S. citizens who hold immigration visas. Of this group, the table immediately above includes only the science and engineering graduates.

Referring again to Figure 3, the dotted extensions of the growth curves, except for the Latins, show a slight upward bend. However, the changes from the trend line are small, indicating a reasonably good match of the 1973 DRF data to the Comprehensive Roster data for earlier periods. The exception, for the Latin group, where a reversal in the growth trend is shown, indicates the probability that, for this group, a partial inclusion of the non-U.S. citizens without immigration visas would provide a better estimate. However, there is no presently-available technique, other than extrapolation of the curves of Figure 3, to suggest what proportion might be suitable. In short, we have partial data from which tentative conclusions might be drawn with respect to growth rates, but more extensive analyses will be required for firm conclusions.

The general conclusion from the above statistics is that there is no evidence of an increasing proportion of science and engineering PhD's from minority groups among the U.S. native population. Increases in these groups over the past several decades have come either from the population of naturalized citizens or those members of the U.S. labor force who have retained their foreign citizenship. These groups are shown in Tables 8 and 9.

Minority Groups and Citizenship in Comprehensive Roster

Tables 8 and 9 are similar in making quite clear that, insofar as the minority groups in U.S. science and engineering are concerned, at the PhD level, the chief increase has come in the Oriental group, for both those who have taken U.S. citizenship and those who have retained citizenship in a foreign country. The trend lines are different, the foreign citizens being clustered much more heavily in the recent graduation cohorts. This would be expected on either of two counts: it takes time to achieve naturalization, and the numbers of foreign citizens who have taken U.S. PhD's have increased greatly in recent years. Whether the latter plan to stay for a long time in the U.S., or only temporarily, they would tend to be found predominantly in the more recent classes. This clustering toward the more recent end of the 40+ year period shown is characteristic of all of the racial/ethnic groups, but most apparent for the Orientals, as their numbers are so much larger.

Table 8

Foreign-Born U.S. Citizens in Comprehensive Roster, by Racial/Ethnic Group and Fiscal Year of Doctorate

Period of Graduation	U.S. Total	Minorities Total	Black	Oriental	Latin	American Indian	Other
1930-34	735	15	0	12	3	0	0
1935-39	919	34	0	31	3	0	0
1940-44	807	86	0	79	5	0	2
1945-49	1358	146	0	111	35	0	0
1950-54	3071	487	0	462	14	0	11
1955-59	3038	519	24	435	46	0	14
1960-64	3866	1030	7	939	79	0	5
1965-69	4607	1467	0	1382	76	0	9
1970-72	2336	649	5	581	63	0	0
TOTAL	20,760	4433	36	4032	324	0	41

Table 9

Non-U.S. Citizens in Comprehensive Roster, by Racial/Ethnic Group and Fiscal Year of Doctorate

Period of Graduation	U.S. Total	Minorities Total	Black	Oriental	Latin	American Indian	Other
1930-34	62	21	0	21	0	0	0
1935-39	49	18	0	18	0	0	0
1940-44	43	4	0	1	3	0	0
1945-49	154	28	0	21	7	0	0
1950-54	572	66	5	51	10	0	0
1955-59	1209	271	13	253	5	0	0
1960-64	2743	852	0	833	15	0	4
1965-69	5615	2660	47	2536	64	5	8
1970-72	4155	2178	54	3039	81	0	14
TOTAL	14,662	6098	119	5763	170	5	26

Table 10

Field of Employment, by Racial/Ethnic Group, in 1973 Comprehensive Roster of Doctoral Scientists and Engineers, with Percentages*

Field of Employment		Racial/Ethnic Group							
		Known Total	White	Black	Oriental	Latin	American Indian	Other	Minorities Total
Mathematics	N	13,811	12,797	132	764	110	0	8	1,014
	%	100.0	92.7	1.0	5.5	.8	0	.1	7.3
Physics	N	15,610	14,534	31	951	69	14	11	1,076
	%	100.0	93.1	.2	6.1	.4	.1	.1	6.9
Chemistry	N	26,224	24,411	313	1,333	162	0	5	1,813
	%	100.0	93.1	1.2	5.1	.6	0	--	6.9
Earth Sci	N	9,528	9,174	23	286	25	0	20	354
	%	100.0	96.3	.2	3.0	.3	0	.2	3.7
Engineering	N	32,592	29,295	87	3,014	144	17	35	3,297
	%	100.0	89.9	.3	9.2	.4	.1	.1	10.1
Biosciences	N	52,982	49,475	486	2,520	441	7	53	3,507
	%	100.0	93.4	.9	4.8	.8	--	.1	6.6
Psychology	N	22,501	21,913	182	222	115	12	57	588
	%	100.0	97.4	.8	1.0	.5	.1	.3	2.6
Social Sci	N	24,122	22,627	281	970	168	44	32	1,495
	%	100.0	93.8	1.2	4.0	.7	.2	.1	6.2
All Other Fields	N	10,184	9,725	121	257	48	0	33	459
	%	100.0	95.5	1.2	2.5	.5	0	.3	4.5
Grand Total		207,554	193,951	1,656	10,317	1,282	94	254	13,603
		100.0	93.4	.8	5.0	.6	--	.1	6.6

* Includes only those for whom both field of employment and racial/ethnic status is known.

The racial/ethnic distribution by field of employment is shown in Table 10. This table includes only those people for whom both racial/ethnic status and field of employment are known, hence the numbers will not necessarily agree with those of previous tables.

There are significant field variations. In psychology and the earth sciences, respectively, only 2.6% and 3.7% of the PhD's are in minority groups, as compared with an overall percentage of 6.6% and with 10.1% in engineering. When the several different racial/ethnic groups are considered, further differences appear. Blacks, for example, are relatively more numerous in math, chemistry, and the social sciences, and are found with

less than expected frequency in physics, earth sciences, and engineering. Orientals, by contrast, are relatively nore numerous in engineering and, to a lesser degree, in physics, and relatively rare in psychology, earth sciences and the social sciences. The Latin contingent is more frequent in the biosciences, and less frequent in the earth sciences and engineering. The number of American Indian respondents in this questionnaire was too small for reliable statistical comparisons (except possibly for the large proportion in the social sciences) but the numbers are included for the sake of completeness. The same might be said for the "all other" group.

Employer Category and Work Activity

As might be expected from the field distribution data of Table 10, the racial/ethnic distributions vary by employer category, as the several groups of employers do not require equal mixes of the various disciplines. Although it would be possible to present data by employer category and racial/ethnic group within disciplines, the resulting numbers would be so small in many cases as to result in unreliable statistics. It must be remembered that the reliability of the statistics is dependent on the actual numbers of the respondents, not the "blown-up" figures in the tables here presented. The numbers that must be used in computing reliability of percentages are roughly one-sixth the size of the numbers in the tables.

Racial/ethnic distributions by employer category and primary work activity are shown in Table 11, which includes data for all the employed and also those not employed for reasons of retirement, inability to locate work, or because they did not indicate employer or work activity. Within each of four major employer categories there is a break-out by primary work activity, i.e., research, administration, teaching, and all other. Only for those in educational institutions is teaching indicated separately. In the other employer categories the small number of those engaged primarily in teaching is lumped into the "all other" category for simplicity. Also

for simplicity, the percentage distribution (vertical percentages) of work activity by racial/ethnic group is given, as this allows the clearest picture of the variations in the employment patterns by racial/ethnic group.

Educational institutions (including elementary and secondary schools) employ proportionately more Blacks and American Indians than other racial/ethnic groups, and this disparity is accounted for primarily by teaching activity. Both groups are low in research activity (for the American Indians, it is zero), but the small numbers of cases make the statistics of research activity in these cases unreliable. A disproportionately large number of Blacks are also employed in administrative capacities in educational institutions. Within this employer category, the Orientals, Latins and the "all other" racial/ethnic groups are more heavily employed in research activity than are members of the majority White population.

The Federal government employs relatively fewer members of minority groups than is true for all employers jointly. This is particularly true of the Orientals, but only marginally true of the Blacks and Latins. Of the Orientals, who work in the Federal government, an unusually large proportion are engaged in research. In administrative activities, none of the minorities reaches the White percentage (2.8%) although the Blacks come close with 2.2%.

Business and industry employs fewer minorities, except for Orientals, than it does Whites, in proportion to their total numbers in the scientific-engineering population. The proportion of Orientals employed by business and industry, however, is surprisingly high, and an unusually large proportion of these are in research work. However, in business and industry, relatively few of any minority racial/ethnic group reach the ranks of administration. For the remaining category of "all other" employers--which includes hospitals, non-profit organizations, and state and local government primarily--the proportions of the several minority groups are in general rather close to

Table 11

Racial/Ethnic Distribution by Employer Category and Primary Work Activity, in the 1973 Comprehensive Roster of Doctoral Scientists and Engineers

Employer and Work Activity		Total	White	Black	Oriental	Latin	American Indian	Other	Minorities Total
GRAND TOTAL	N	226,095	211,408	1,861	11,004	1,419	105	298	14,687
	H%	100.0	93.5	.8	4.9	.6	-	.1	6.5
	V%	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0
Educational Institutions (Total,All Activities)	N	122,288	114,334	1,186	5,751	784	73	160	7,954
	H%	100.0	93.5	1.0	4.7	.6	.1	.1	6.5
	V%	54.1	54.1	63.7	52.3	55.3	69.5	53.7	54.2
Research	N	25,472	23,501	96	1,630	201	0	44	1,971
	V%	11.3	11.1	5.2	14.8	14.2	0	14.8	13.4
Teaching	N	73,856	69,389	734	3,130	437	73	93	4,467
	V%	32.7	32.8	39.4	28.4	30.8	69.5	31.2	30.4
Administration	N	10,557	10,152	185	166	44	0	10	405
	V%	4.7	4.8	9.9	1.5	3.1	0	3.4	2.8
All Other	N	12,403	11,292	171	825	102	0	13	1,111
	V%	5.5	5.3	9.2	7.5	7.2	0	4.4	7.6
Federal Government (Total,All Activities)	N	18,531	17,746	146	516	100	3	20	785
	H%	100.0	95.8	.8	2.8	.5	-	.1	4.2
	V%	8.2	8.4	7.8	4.7	7.0	2.9	6.7	5.3
Research	N	9,367	8,880	74	328	70	0	15	487
	V%	4.1	4.2	4.0	3.0	4.9	0	5.0	3.3
Administration	N	6,091	5,977	41	55	12	1	5	114
	V%	2.7	2.8	2.2	.5	.8	1.0	1.7	.8
All Other	N	3,073	2,889	31	133	18	2	0	184
	V%	1.2	1.4	1.7	1.2	1.3	1.9	0	1.3
Business and Industry (Total,All Activites	N	47,326	43,697	250	3,114	204	5	56	3,629
	H%	100.0	92.3	.5	6.6	.4	-	.1	7.7
	V%	20.9	20.7	13.4	28.3	14.4	4.8	18.8	24.7
Research	N	15,454	13,922	63	1,378	77	0	14	1,532
	V%	6.8	6.6	3.4	12.5	5.4	0	4.7	10.4
Administration	N	16,377	15,802	89	412	55	0	19	575
	V%	7.2	7.5	4.8	3.7	3.9	0	6.4	3.9
All Other	N	15,495	13,973	98	1,324	72	5	23	1,522
	V%	6.9	6.6	5.3	12.0	5.1	4.8	7.7	10.4
All Other Employers (Total,All Activities)	N	22,453	20,962	133	1,102	206	16	34	1,491
	H%	100.0	93.4	.6	4.9	.9	.1	.2	6.6
	V%	9.9	9.9	7.1	10.0	14.5	15.2	11.4	10.2
Research	N	6,638	6,036	31	498	60	12	1	602
	V%	2.9	2.9	1.7	4.5	4.2	11.4	.3	4.1
Administration	N	4,999	4,828	33	88	33	4	13	171
	V%	2.2	2.3	1.8	.8	2.3	3.8	4.4	1.2
All Other	N	10,816	10,098	69	516	113	0	20	718
	V%	4.8	4.8	3.7	4.7	8.0	0	6.7	4.9
Not Employed (Retired,Unemployed & no response to employment item)	N	15,497	14,669	146	521	125	8	28	828
	H%	100.0	94.7	.9	3.4	.8	.1	.2	5.3
	V%	6.9	6.9	7.8	4.7	8.8	7.6	9.4	5.6

H% = Percentage by racial/ethnic group within employment category
V% = Percentage by employment category within racial/ethnic group

the Grand Total figures. However, they are employed in "all other" activity--as contrasted with research, administration or teaching--in an even higher concentration than is found in business and industry, which makes it difficult to characterize the employment.

While it would be possible to set up a Chi Square table for this group, similar to that shown in Table 5 for the 1973 graduates, showing the disparity in employment after correcting for the field distribution requirements of the various employer categories, this entails technical difficulties because of the fact that we are dealing with a weighted sample, rather than either the base population or a random sample. Inasmuch as the technical questions thus induced are not negligible, it was deemed preferable to leave this matter to a more detailed later analysis. The numbers in the preceding tables are felt to be sufficient for the immediate purpose of showing the situation as it exists, so that those who have a need for the data may have them and make their own interpretations.

SUMMARY

This is a brief first report on racial/ethnic groups at the PhD level in the United States. The data banks which were used for this report have a great deal more information, which will be analyzed and reported as time permits. A summary of the present information seems in order at this point, however.

- Self-designation is accepted as superior to indirect methods of determination or estimation of ethnic or racial affiliation, for individual or statistical purposes. It is the method used herein.
- Because foreign nationals who earn U.S. doctorates have a different racial/ethnic mix than do U.S. citizens, citizenship as well as racial/ethnic status must be considered in estimating additions to the U.S. labor force at the PhD level.
- The Doctorate Records File of the Commission on Human Resources provides complete coverage of new PhD's, and the Comprehensive Roster of Doctoral Scientists and Engineers has an intensive representative sample of the existing supply of PhD's in the scientific-technical fields, with data on racial/ethnic identification--the first comprehensive data available at this level.
- Almost 4,000 of the PhD's of fiscal 1973 in the United States were members of minority groups but only 37% of these were U.S. citizens. The Orientals were the predominant group, followed by Blacks, Latins and American Indians, in that order.
- Discipline concentrations vary for the various racial/ethnic groups. Orientals tend to favor the physical sciences and engineering; Blacks and American Indians concentrate more in education, and Latins in the humanities, if they are U.S. citizens or hold immigration visas, and in the natural sciences if they are citizens of other countries without immigration visas.

- Numbers by employer categories, for the new graduates, are not proportionately distributed across the racial/ethnic groups. For instance, Blacks tend to concentrate in educational institutions, and Orientals in business and industry. All minority groups except Blacks are found in greater than expected numbers in postdoctoral training.

- Within the sciences and engineering fields, evidence from the periods of graduation of the present supply of PhD's indicates that the growth rate for the various minorities has been more rapid over the past forty years than it has been for the majority white population. This increased growth rate comes primarily from the ranks of immigrants, rather than from the native U.S. population.

- Minority groups comprise 6.6% of the U.S. PhD-level science and engineering labor force; Orientals furnish 5 percentage points of this group, Blacks .8, Latins .6, American Indians less than .1 and all other minority racial/ethnic groups approximately .1. These groups are not proportionately distributed across the several disciplines, nor within employer categories nor primary work activities, but with variations that apparently arise from multiple causes.

- This scientific and engineering population was analyzed in terms of period of graduation, to furnish an approximation to growth rate data. This showed an increase in minority-group members in this group that has been more rapid than the increase of the White majority, but these rates of increase have come principally from the "brain drain" from foreign countries, rather than from the U.S. native population, in which the minority-group rates of increase are, with one exception, lower than that for Whites.

Appendix 1

Estimation Techniques: Direct and Indirect

Prior to the availability of direct self-designation methods, various techniques had been developed to estimate the numbers of various minority groups from data known to be correlated with racial or ethnic status. Two of these procedures, based respectively on educational careers and on analysis of names, are described below, with some indication of their limitations for the present purpose.

Educational Patterns

Over most of the southern United States, racially-segregated education prevailed for all of this century up to the desegregation decisions of the Supreme Court. Desegregation began at the graduate school and professional school level, and gradually progressed down to the elementary school level. These same states, with de jure segregation, included the vast majority of the Black population of the United States. It was thus possible, by examining a person's educational history during this period, to make a reasonable inference as to his racial identification. In the northern and border states, de facto segregation was practiced at the elementary and high school levels, largely because of the segregated residential pattern. However, there could never be real assurance that the data derived from analyses of educational background were adequate, simply because a portion--of unknown size--of the Black population has always attended non-segregated schools.

With the advent of self-designation on the 1973 Survey of Earned Doctorates and the Comprehensive Roster questionnaire, it became possible to check the "educational pattern" method of identification against the criterion of self-designation. Analysis in this manner by CHR staff showed that the most accurate identification was based on the high school from which a person graduated, the next most accurate on institution of baccalaureate, while less accuracy attended identification based on graduate school(s) attended, or institution of employment. Combinations of several

levels of educational/employment experience improved the indentification somewhat, but there were many individuals who identified themselves as Black who had no formal contact with "predominantly Black" institutions. For example, of the 575 individuals in the 1973 Survey of Earned Doctorates who identified themselves as Black, 375 had some formal contact with a Black institution; 200 did not. Contrariwise, there were 249 cases of people who did not identify themselves as Black, but who had some such formal contact (90 of them for employment only).

A further practical difficulty in using this technique arises from the fact that, in recent years, the high school of origin has not been coded in the Survey of Earned Doctorates, although it is on the original records and could be retrieved if necessary. The final result of this analysis is that such circuitous means are far less satisfactory than direct self-designation, and cannot be depended upon to provide consistent time trends, geographic data, or even adequate over-all percentage statistics.

Spanish Surnames

An entirely different method has been used in some cases for identifying the people of Spanish-speaking origin--Chicanos, Puerto Ricans, Cubans or people from other Central or South American countries, a group for which this report will use the generic term "Latins". Most people from these areas have Spanish surnames. Hence Spanish surnames have been used as a method of identifying this population sub-group. Apart from the problem of compiling a list of names that are unquestionably Spanish and sufficiently comprehensive, there are other problems based on the existence of such names among population groups which have only partial or distant identification with any underprivileged minority--or among such distinctly different minorities as Filipinos. An Air Force study[1] which employed several computerized techniques for recognizing Spanish names, compared them with self-designations, and came to the conclusion that the system worked well only in the Southwest states for people of limited education--

(1) Manpower Research Report No. MA 73-2, A Comparison of Computerized Techniques for Recognizing Spanish Names. Office of Secretary of Defense. October 1973

a restriction that would clearly exclude the U.S. PhD population. This finding was checked with the advent of self-designation procedures for the Doctorate Survey and Comprehensive Roster survey in 1973. It was found that neither Spanish surnames, nor techniques based on letter-combinations were valid. Either method, or both in combination, missed about one-third of the cases it was supposed to identify, while mis-identifying from 100% to 250% as many cases as it should have picked out. It was concluded, therefore, that this method is grossly inadequate when applied to the U.S. doctorate population.

The educational-background method was also tried out for identification of American Indians who came through schools on Indian reservations. This, too, proved to be thoroughly inadequate, and was quickly abandoned.

Other techniques are available, and have been used by various investigators. One excellent study, made some years ago by a Black scientist[1] used word-of-mouth and mail communication for original identification of Black PhD scientists, and verified the identification by direct contact with the individuals designated. With such a procedure, one can be sure that all individuals included belong in the specified group. One cannot, however, be sure that others have not been omitted who could validly have been included.

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(1) Negroes in Science: Natural Science Doctorates, 1876-1969, by James M. Jay, Balamp Publishing, Box 7390, Detroit, Michigan 48202, 1971.

Appendix 2

Minority Group Estimates from Incomplete Data

The data used in this report are never based on complete coverage, although for the 1973 Survey of Earned Doctorates the data come close to being complete. It is useful, in using such incomplete data, to have an estimate of the random sampling error introduced by the extent to which the actual data represent less than 100% coverage. If there were complete "census" coverage, of course, there would be no room for errors of random sampling, and even very tiny proportions would be an accurate representation of reality. Where the sampling ratio is large, as it is for the 1973 Survey of Earned Doctorates, a reduction in the normal value of the standard error of a proportion is substantial. This reduction is given by the formula:

#1 $$\sqrt{\frac{\text{Population-Sample}}{\text{Population - 1}}} \quad \text{or} \quad \sqrt{\frac{33{,}014-25{,}055}{33{,}013}} = \sqrt{.241} = .491$$

The standard error of any proportion, assuming a random sampling from an indefinitely large population, is given by the familiar formula.

#2 $$\sqrt{\frac{pq}{N_s}}$$ where p is the proportion of any group and q is the complement and N_s is the number in the sample

Applying these formulae to the three citizenship groups in the 1973 DRF data, one obtains corrections via formula #1 above as follows:

	Total	Racial/Ethnic data known	Correction
U.S. Native citizens	27,868	21,536	.477
Non-US, Immigrant Visas	1,986	1,444	.522
Non-US, Non-Immigrant	3,162	2,075	.586

The data for use with formula #2 vary, of course, by racial/ethnic group within each citizenship group. The standard errors to be applied to each of the citizenship X racial/ethnic groups in Table 1 in the text are given in Appendix 2, Table 1, below.

APPENDIX TABLE 1

Standard Errors Accompanying the Racial/Ethnic Data of Table 1, Page 8 by Citizenship Groups

Numerical Error and Relative Error in Percentage

		White	Black	Oriental	Latin	American Indian	All Other
US Citizens	N	15.2	1.9	.8	.6	.4	.0
	%	.1	.3	.3	.3	.3	.3
Non-US, Immigrant Visas	N	6.3	1.1	7.2	.2	---	.1
	%	1.0	.6	.9	1.4	---	1.4
Non-US Non-Immigrant Visas	N	10.0	1.3	7.2	.8	.0	.4
	%	.8	1.3	1.1	1.3	1.3	1.3

For those who wish to compare the data of the present report with those of the Summary Report, 1973, Doctorate Recipients from United States Universities, the pages of that report relating to racial or ethnic group are reproduced on the following two pages.

APPENDIX TABLE 2

Field of PhD by Racial/Ethnic Group, 1973 Summary Report

Racial/Ethnic Group		FIELD OF DOCTORATE Phys. Scnes	Engr.	Life Scnes	Social Scnes	A & H	Prof. Fields	Educ.	Total	
White/Caucasian	No.	3396	1902	3185	4069	3894	994	4811	22251	
	H%	15.3	8.5	14.3	18.3	17.5	4.4	21.6		
	V%	78.3	69.5	78.2	84.8	87.3	86.6	84.9	81.7	
Black/Negro/Afro-Amer.[a]	No.	45	27	96	87	74	24	382	735	
	H%	6.1	3.7	13.1	11.8	10.1	3.1	52.0		
	V%	1.0	1.0	2.4	1.8	1.7	2.1	6.7	2.7	
American Indian[b]	No.	10	7	17	21	18	1	34	108	
	H%	9.3	6.5	15.7	19.4	16.7	.9	31.5		
	V%	.2	.3	.4	.4	.4	.1	.6	.4	
Span.-Amer./Mex.-Amer./ Chicano[c]	No.	35	14	49	26	49	4	38	215	
	H%	16.3	6.5	22.8	12.1	22.8	1.9	17.7		
	V%	.8	.5	1.2	.5	1.1	.4	.7	.8	
Puerto Rican-American[d]	No.	3	3	7	8	6		10	37	2884
	H%	8.1	8.1	18.9	21.6	16.2		27.0		
	V%	.1	.1	.2	.2	.1		.2	.1	
Oriental[e]	No.	480	476	372	190	84	36	93	1731	
	H%	27.7	27.5	21.5	11.0	4.9	2.0	5.4		
	V%	11.1	17.4	9.1	4.0	1.9	3.0	1.6	6.4	
Other	No.	10	17	7	8	11	1	4	58	
	H%	17.2	29.3	12.1	13.8	19.0	1.7	6.9		
	V%	.2	.6	.2	.2	.2	.1	.1	.2	
No Useable Response	No.	359	292	340	387	325	91	298	2092	
	H%	17.2	14.0	16.3	18.5	15.5	4.2	14.2		
	V%	8.3	10.7	8.3	8.1	7.3	7.8	5.3	7.7	
Total	No.	4338	2738	4073	4796	4461	1151	5670	27227	
	H%	15.9	10.1	15.0	17.6	16.4	4.1	20.8		
	V%	100.0	100.1	100.0	100.0	100.0	100.1	100.1	100.0	

NOTE: H% indicates the horizontal percentages which sum to 100% across the doctoral fields for each racial/ethnic group. The vertical percentages (V%) sum to 100% for each doctoral field.

[a] Includes 7 persons who checked this category and one other.
[b] Twenty persons checked only this category; 88 checked American Indian and White.
[c] Includes 45 persons who checked this category and White.
[d] Eight persons in this category also checked White.
[e] Twelve persons checked this category and White.

APPENDIX TABLE 3

Profile Data on FY 1973 Doctorate Recipients

Reporting a Minority Racial or Ethnic Group Identification

	U.S. Citizens		Non-U.S. Citizens		TOTAL*	
	No.	%	No.	%	No.	%
TOTAL	1134	100.0	1726	100.0	2884	100.0
Black/Negro/Afro-American	581	51.2	144	8.3	735	25.5
American Indian	107	9.4	1	-	108	3.7
Span.-Amer./Mex.-Amer./Chicano	135	11.9	79	4.6	215	7.5
Puerto Rican-American	36	3.2	-	-	37	1.3
Oriental	251	22.1	1468	85.1	1731	60.0
Other	24	2.1	34	2.0	58	2.0
Sex						
Male	868	76.5	1556	90.2	2443	84.7
Female	266	23.5	170	9.8	441	15.3
Doctoral Field						
Physical Sciences	118	10.4	461	26.7	583	20.2
Engineering	84	7.4	456	26.4	544	18.9
Life Sciences	160	14.1	385	22.3	548	19.0
Social Sciences	158	13.9	179	10.4	340	11.8
Arts & Humanities	143	12.6	95	5.5	242	8.4
Education	443	39.1	113	6.5	561	19.5
Professions	28	2.5	37	2.1	66	2.3
Median Age at Doctorate	35.0 years		31.7 years		32.5 years	
Median Time Lapse from Baccalaureate to Doctorate						
Total Time	11.3 years		8.4 years		9.2 years	
Registered Time	6.2 years		5.6 years		5.8 years	
Postgraduation Plans						
Study appointment	158	13.9	576	33.4	734	25.4
Employment	933	82.3	1083	62.7	2030	70.4
R & D	151	16.2	409	37.8	564	27.8
Teaching	453	48.5	422	39.0	880	43.3
Administration	153	16.4	23	2.1	176	8.7
Professional services	54	5.8	60	5.5	115	5.7
Other	31	3.3	48	4.4	80	3.9
Unknown	91	9.8	121	11.2	215	10.6
No report of plans	43	3.8	67	3.9	120	4.2
Postgraduation Location						
U.S.	860	75.8	723	41.9	1592	55.2
Foreign country	19	1.7	458	26.5	480	16.6
Unknown	255	22.5	545	31.6	812	28.2

*The total includes 24 persons who did not report their citizenship at time of doctorate.

For the data of the Comprehensive Roster survey, the sampling ratio was not so high, being only about one-in-six originally, with a non-response group further decreasing the sample. However, as the samples were still very large, the relative error is small, as described in Appendix A, Table A-2 of Doctoral Scientists and Engineers in the United States, 1973 Profile. The following table is copied from that report.

APPENDIX TABLE 4

1930-72 United States Doctoral Scientists and Engineers :
Random Sampling Error for Varying Statistics and Population Sizes

		POPULATION SIZE		
		244,900	66,400	17,800
REPORTED STATISTIC	1 or 99%	.00047	.00091	.00176
	3 or 97%	.00080	.00164	.00302
	10 or 90%	.00141	.00288	.00531
	25 or 75%	.00203	.00415	.00767
	50%	.00235	.00480	.00886

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